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# **New Method for Quantifying Ignition Sensitivity from Electrostatic Discharge**

**by Eric S Collins, Jennifer L Gottfried, and Eric C Johnson**

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# **New Method for Quantifying Ignition Sensitivity from Electrostatic Discharge**

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## 1. Introduction

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The safety of energetic materials (EMs) is a primary focus for the military and all personnel in close proximity to EMs. Several standardized tests are performed on all EMs including impact, friction, and electrostatic discharge (ESD) sensitivity to ensure that the ignition sensitivity of each EM falls below the safety thresholds and is therefore considered safe to handle. This study investigates a new approach to quantify the ESD and subsequent ignition of the EM, where an ignition sensitivity threshold based on the response measured by a photo receiver can be used to help determine whether or not the EM ignited.

## 2. ESD Apparatus

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The ESD sensitivities of several EMs were tested using an ESD tester, which consisted of a discharge pin as an upper electrode and a sample holder as a lower (cathode) electrode, as shown in Fig. 1. A charged storage capacitor was connected to the discharge pin that was lowered toward the sample. As the discharge pin approached the sample, an electric spark discharged through the sample to the grounded sample holder. Upon discharge, the EM either ignited (“Go”) or did not ignite (“No Go”), depending on its ESD ignition sensitivity and the energy of the electric spark. Standard methods for ESD testing are described in detail in MIL-STD-1751A.<sup>1</sup> The military specifications do not describe the criteria to be used to determine Go or No Go; they only specify that the criteria should be reported.

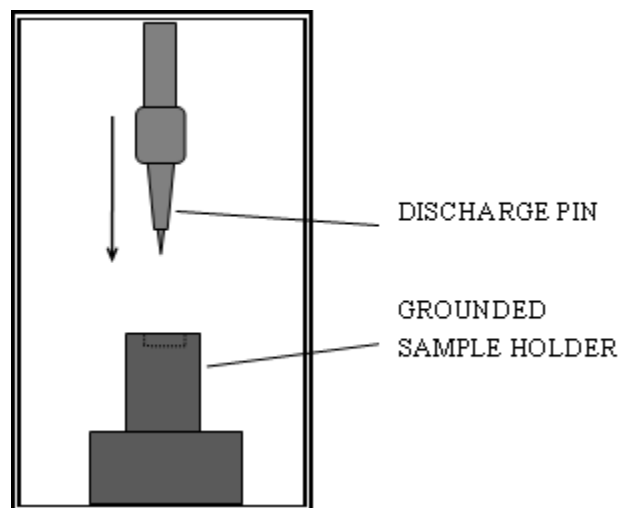


Fig. 1 Diagram of ESD tester

When preparing the EM sample for ESD tests, about 20 mg of loose powder was placed on the sample holder and covered with single-sided adhesive tape to confine the EM powder. The energy output of the discharge was varied to establish a minimum energy required to ignite the EM.

The method previously used at the US Army Research Laboratory to determine the Go or No Go ignition of the EM was through observation of the damage done to the tape by the ESD and burning of EM. Examples of damage to the tape to determine Go or No Go ignition of the EM are shown in Fig. 2. An additional indicator of ignition is through observation of the scattering of the powder, which typically coincides with the damage to the tape. These methods are subjective, and the criteria for Go and No Go could be different for all technicians conducting experiments. In addition, no written record of the visual observations for each postdischarge sample (including multiple repetitions) is saved.

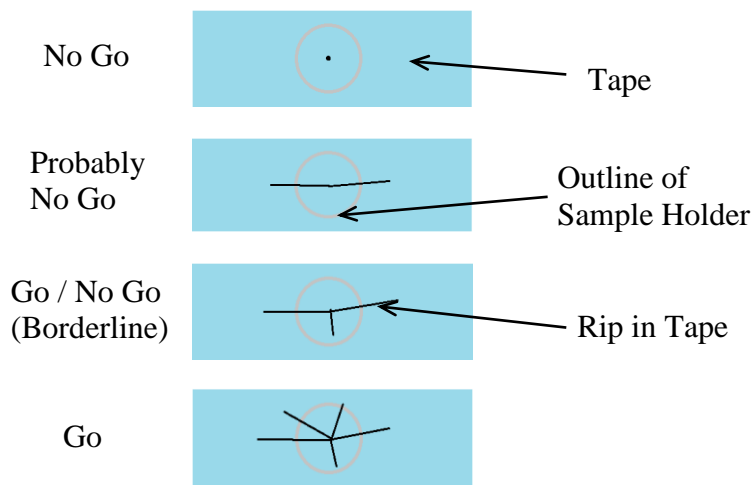


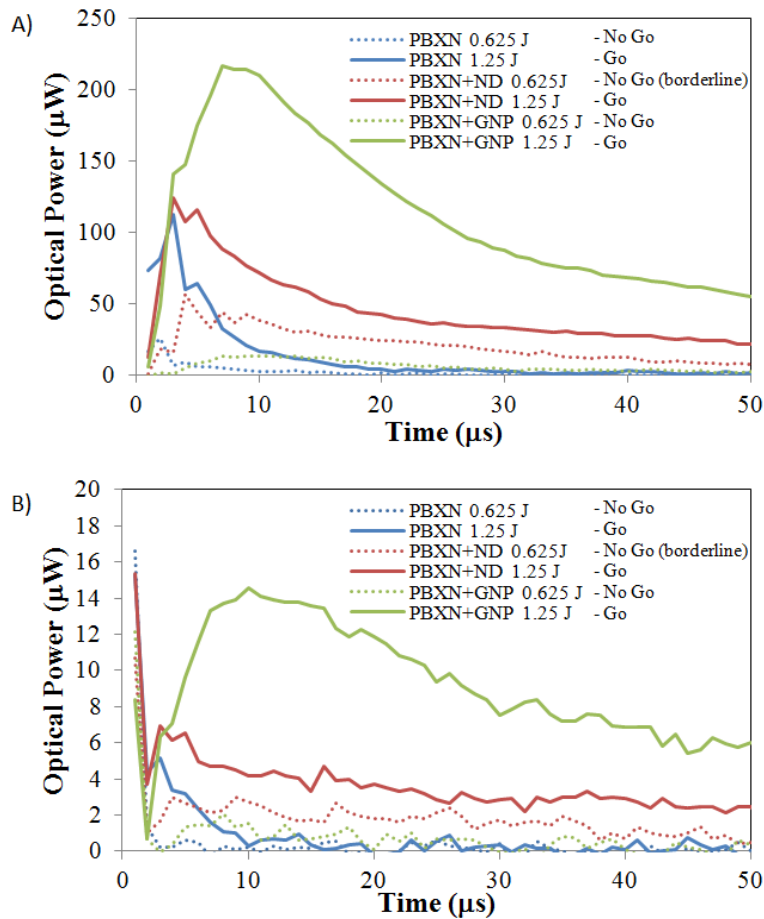
Fig. 2 Criteria for determining ignition of EM using the ESD tester

### 3. Methods and Results

The EM used in this study was PBXN-5, which consists of 95% cyclotetramethylenetetranitramine and 5% binder. Graphite nanoparticles (GNPs) and nanodiamonds (NDs) were added to the PBXN-5 at optimal concentrations of 15%.<sup>2</sup> Photo receivers were used to capture the light emission from the discharge and subsequent deflagration of the EM as a quantifiable method to determine the ESD ignition sensitivity of the EM. Two New Focus photo receivers were placed outside the protective window of the ESD tester and provided visible and infrared time-resolved light intensity with wavelengths between 300 and 1070 nm (model 2051) and 900 and 1700 nm (model 2053), respectively. The voltage responses of the photo receivers were recorded on an oscilloscope and transferred to a computer for analysis.



For PBXN-5, PBXN-5 + ND, and PBXN-5 + GNP, it was observed (using the traditional tape damage method) that the minimum ignition energy was between 0.625 J and 1.25 J (energies between 0.625 and 1.25 J could not be selected with the ESD instrument). The time-resolved optical powers for all samples, calculated from the visible and infrared light intensities from the photo receivers, are shown in Fig. 3. Both photo receivers captured an increase of light intensity for the samples that experienced ignition, suggesting that they could be used to quantify ESD sensitivity of EM.



**Fig. 3** Optical power of ESD and EM burning captured from the a) visible light photo receiver and b) infrared light photo receiver

In addition to quantifying the ESD sensitivity, utilizing the photo receivers would also clarify the uncertainty in the tests between Go and No Go using the damaged tape method (refer to Fig. 2). For example, depending on where the optimum ignition threshold lies (to be determined from multiple tests using standard EMs), PBXN-5 + ND in Fig. 3 would be considered Go or No Go instead of borderline. Based on the comparison between the Go/No Go determined by visual observation of the damaged tape and the emission traces in Fig. 3, it appears that the peak emission intensity (as opposed to the total light emission) correlates most closely to tape damage. In other words, the PBXN-5 at 1.25 J was considered a clear Go even though the emission intensity of the PBXN-5 + ND at 0.625 J was larger at later times (indicating extended combustion) but was considered borderline Go/No Go. The ignition delay (i.e., time to peak emission intensity) could also provide useful information relating to the ignition sensitivity of the EM (e.g., the ignition delay is longer for PBXN-5 + GNP). Such information is not available from visual observation of the postdischarge sample.

#### **4. Conclusion**

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ESD ignition sensitivity tests were conducted on PBXN-5, PBXN-5 + ND, and PBXN-5 + GNP to investigate the utility of photo receivers for a quantitative analysis of the ESD and subsequent ignition of EM. The results show that the photo receivers can be used for a nonsubjective Go or No Go decision on the ignition of the EM. They can also be used to clarify tests that result in borderline Go or No Go through quantitative threshold selection, provide additional information about time to ignition, and improve reproducibility of test results (by using an average emission intensity over multiple discharge events). This new method of quantifying the ESD ignition sensitivity will help accurately determine the minimum ignition energy of EMs to ensure the safety of all personnel handling EMs.

## 5. References

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1. MIL-STD-1751A. Department of defense test method standard: safety and performance tests for the qualification of explosives (high explosives, propellants, and pyrotechnics). Alexandria (VA): Department of Defense; 2001 Dec 11.
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